Cyrano Sciences

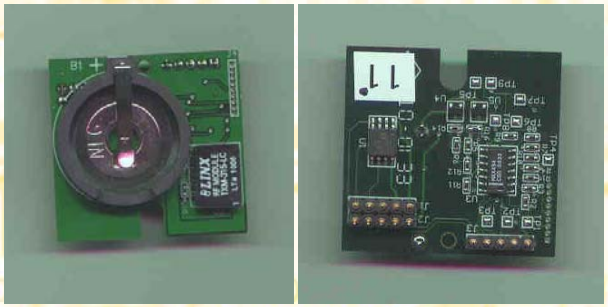
Array Based Chemiresistor Sensors for Residual Life and End of Service Life Indication

October 17, 2002

Product Platforms

Cyranose™ 320

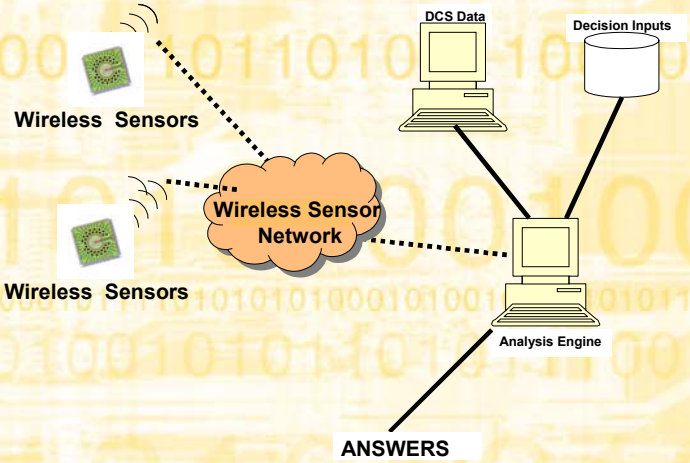
NoseChip™



Front Back

- 4 to 16 Sensors
- < 1 cm; Low Power
- Wireless Comm. to 300 ft
- Disposable
- Integrated Systems

Sensigent™



- Data Fusion

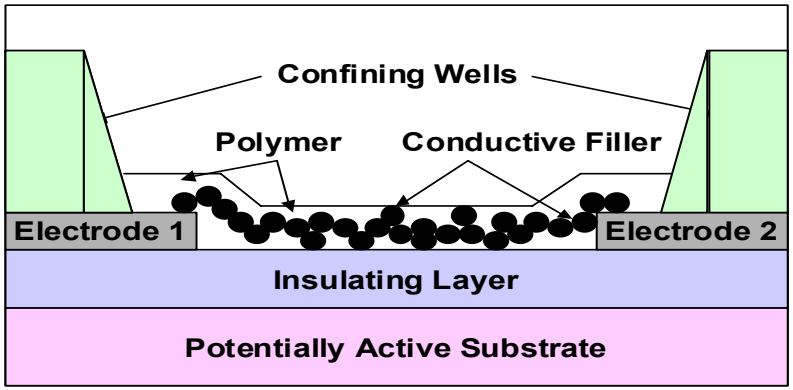
Handheld Point Detector / Identifier

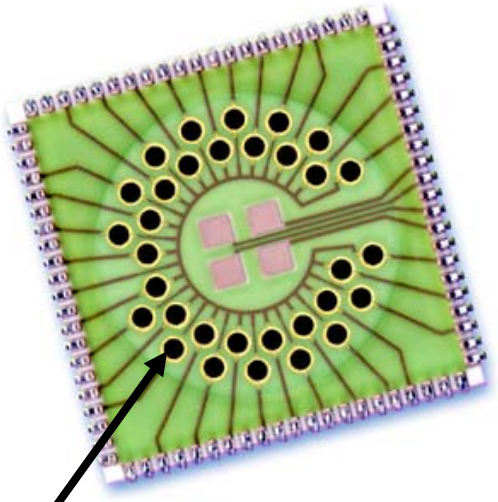
Intelligent Sensor Networks

Cyrano Sensor Technology

Polymer Composite Sensor Array

Sensor Construction

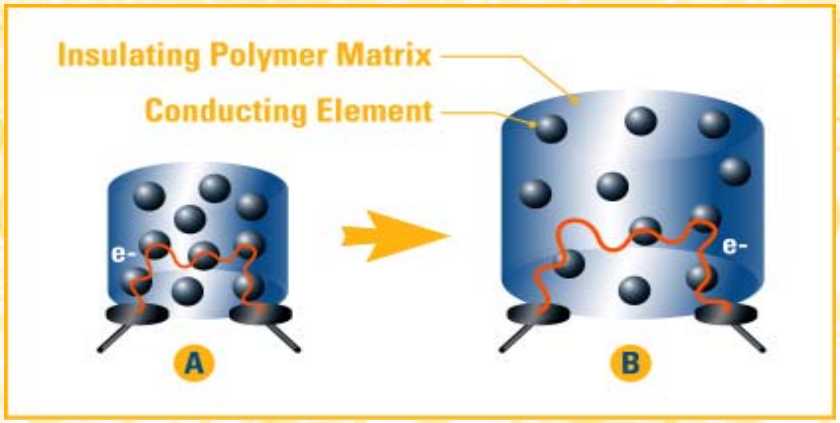




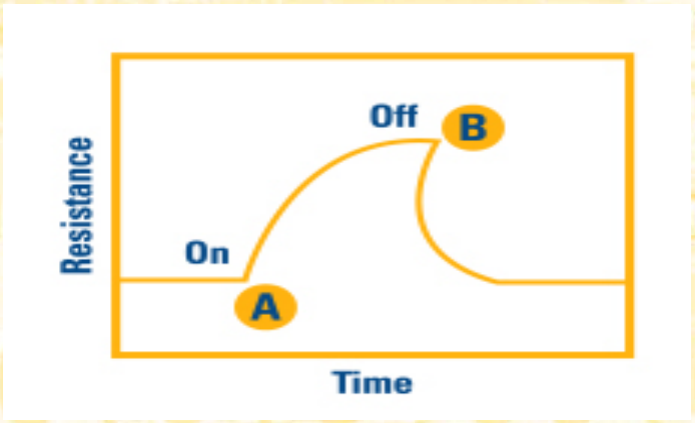
Conductive Polymer Composite

Cyrano Sensor Technology

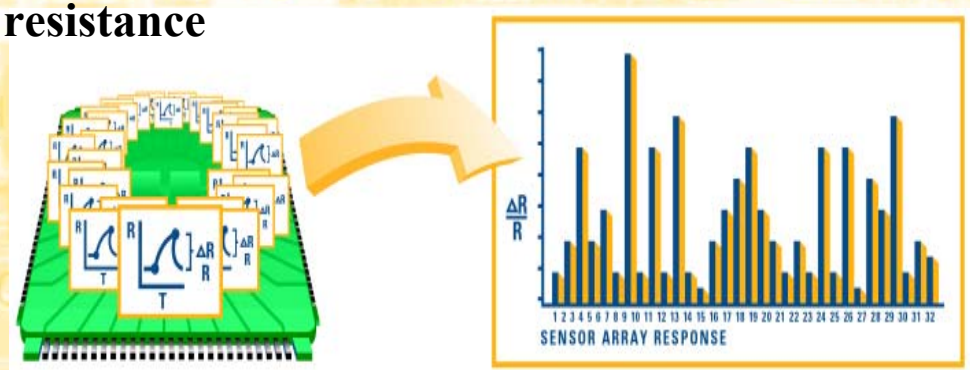
Array Based Chemical Sensing



Vapors pass over the polymer composite sensors; swelling produces a change in resistance



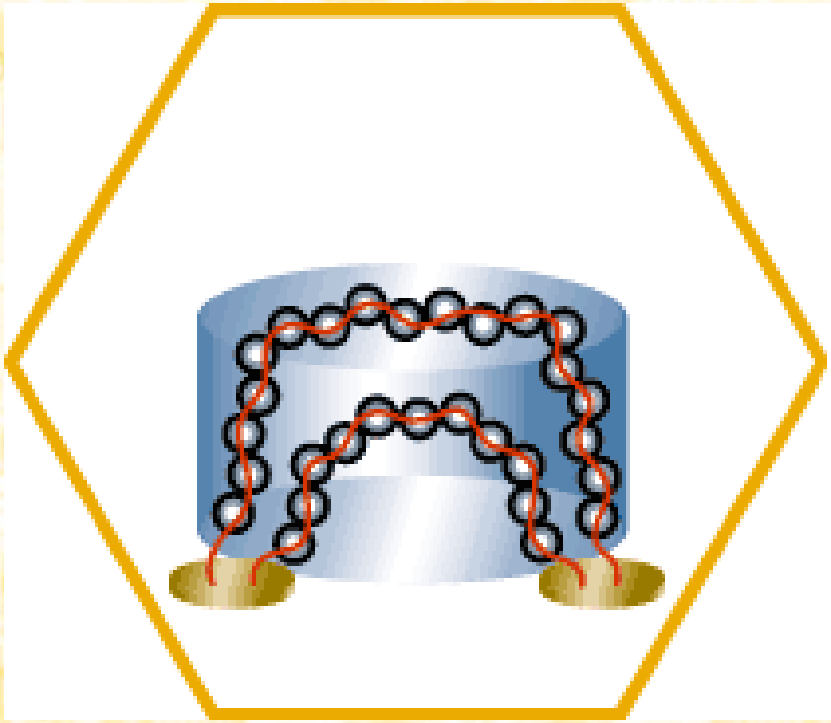
Resistance change is measured for each of the 32 sensors

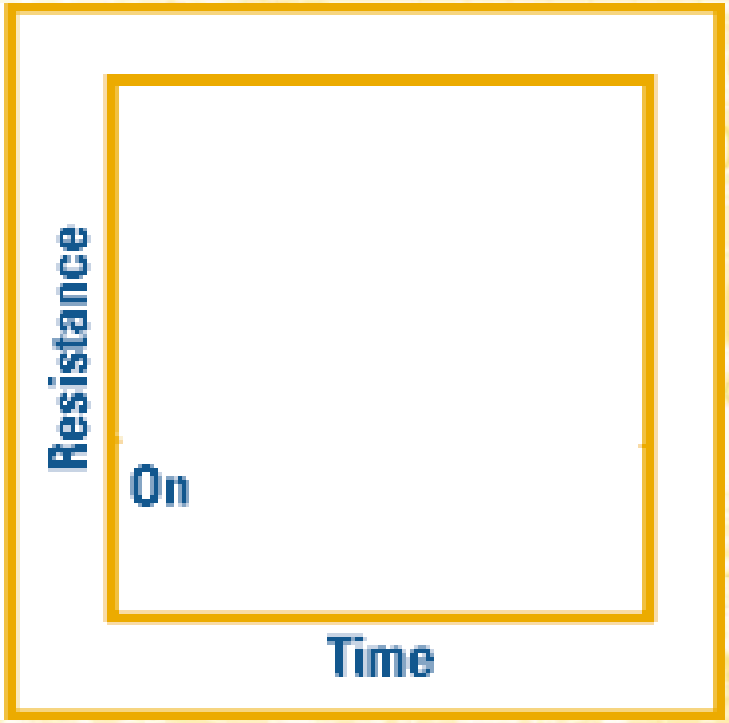


Using pattern matching algorithms, the data is converted into a unique response pattern

Cyrano Sensor Technology

A resistive measurement is taken for each of the 32 sensors:

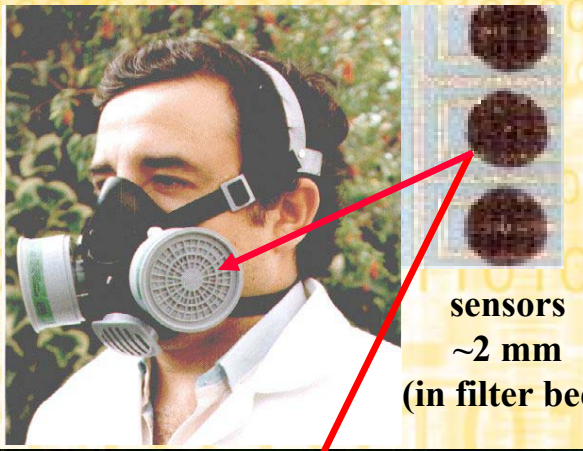




The vapor passes over the polymer matrix and the swelling produces a change in resistance

A relative resistance measurement is made for each of the 32 sensors

RLI Prototype Development



sensors
~2 mm
(in filter bed)

Cyrano RLI sensors

- disposable inside filter cartridge
- intrinsically safety
- sensor spot < 1 mm

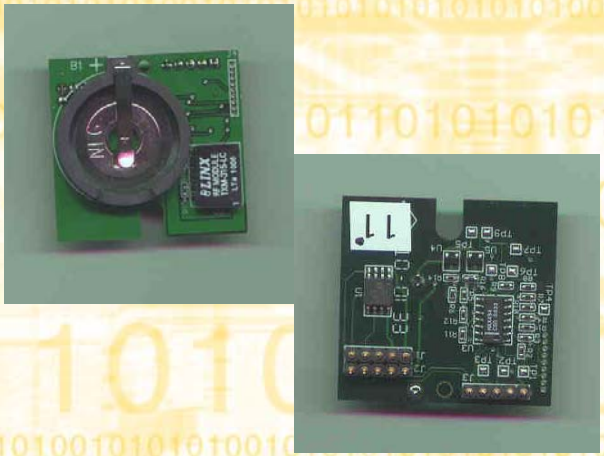
Alarm !
RLI %, unit ID, date & time

Cyrano RLI annunciator

- durable inside mask
- wireless TX/RX

power: micro Watts
battery: weeks to > 1 year

Cyrano NoseChip™



Features:

- Sensor array; tunable
- Low cost & Low power
- Wireless communication
- < 3 cm
- Capable of integration

Applications:

Individual Protection

- Filter RLI / ESLI - NIOSH
- Personal badges - CBIRF

Collective Protection

- Filter Monitoring in field shelters and buildings

Distributed Wireless Monitoring

- Permanent Installations (buildings)
- Temporary Networks (events)

Filter Breakthrough Testing

- **Naval Research Laboratory** –

Comparison of sensor technologies for individual and collective protection

- **NIOSH** –

Contract awarded to Cyrano Sciences for prototype RLI for personal protective equipment

- **NASA** –

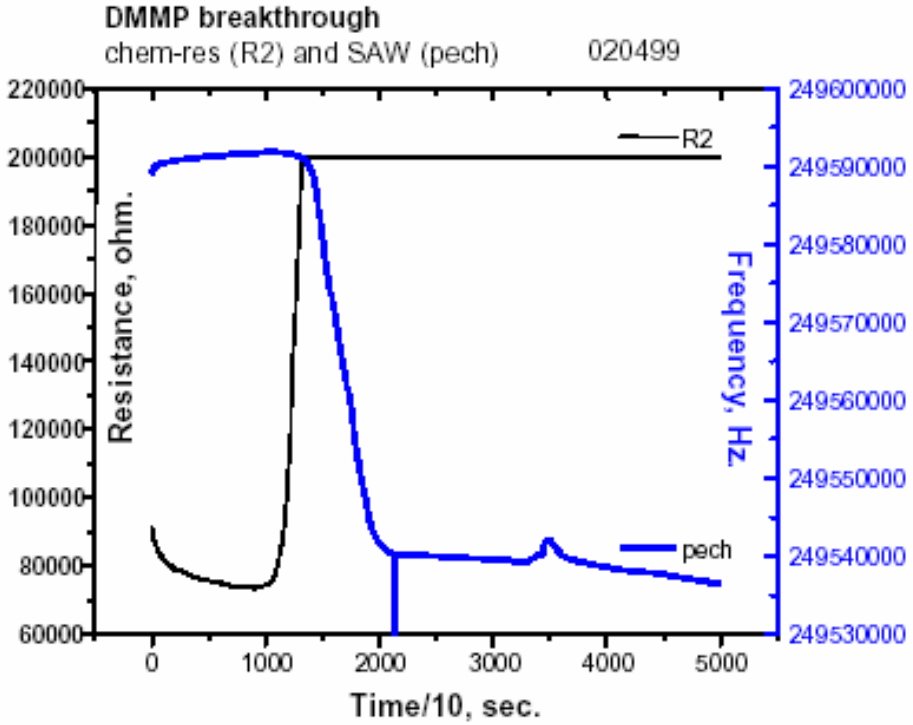
Detection of filter breakthrough detection in animal housing experiments

Filter Breakthrough Testing

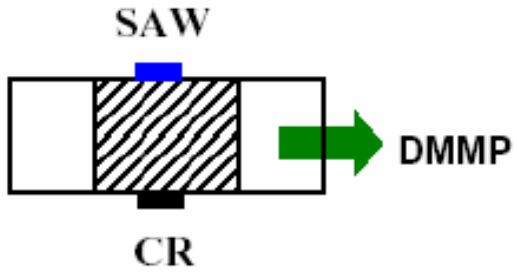
Naval Research Laboratory

- Comparison of Cyrano chemiresistor, SAW, PID and colormetric sensors
- Challenge Vapor: DMMP
- Cyrano's sensors perform as well as SAW sensors
  - ➢ Fast, sensitive response
- Internal testing shows Cyrano sensors use 300% less power than SAW sensors

NRL Filter Breakthrough Tests*

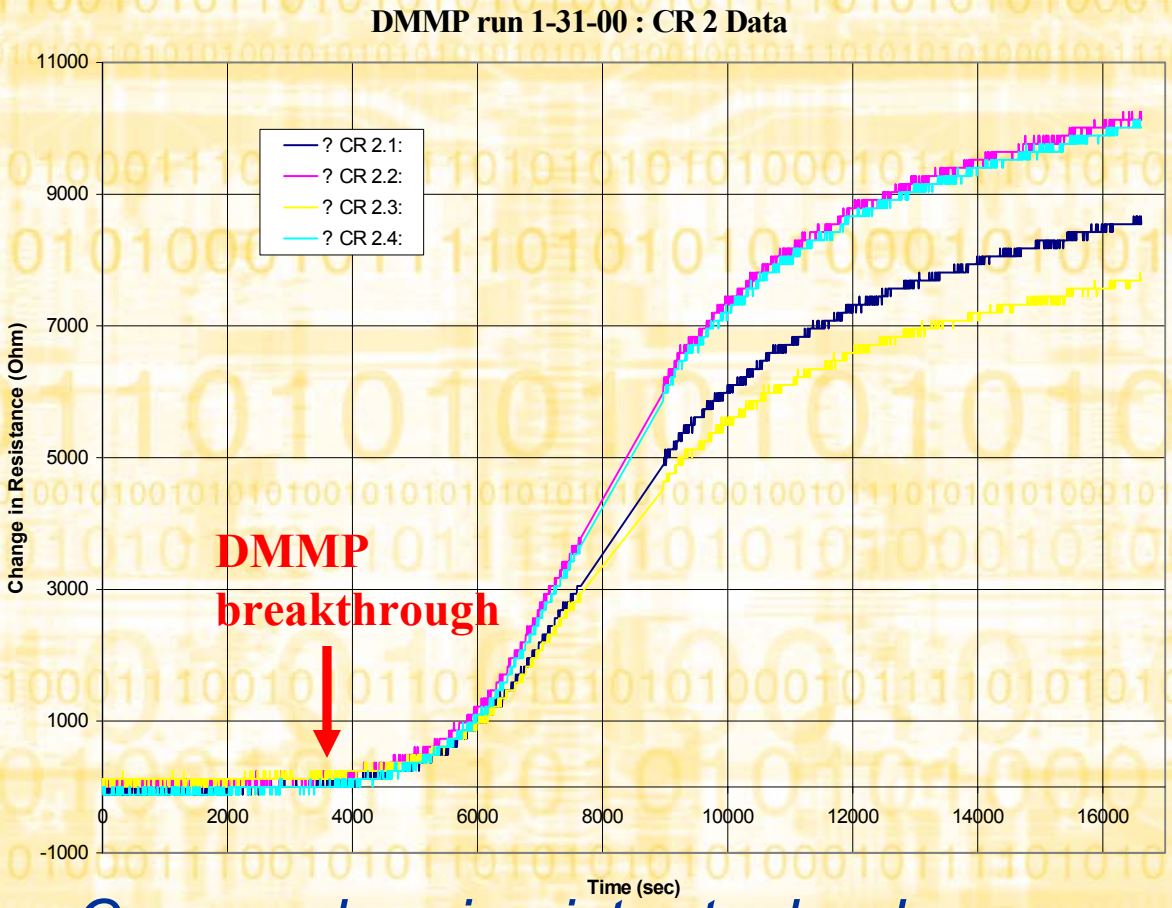


Frequency (SAW) and resistance (Chemiresistor) change upon DMMP breakthrough.
DMMP concentration = 1500 mg/m³. Flow rate = 10 lpm. T = 21°C, %RH = 25%.
Sensors position = middle of 5 cm bed (2.5 cm from the bottom), flush mounted.
Breakthrough time = 10000 sec.



Cyrano chemiresistor sensors are as sensitive and respond as rapid as SAW sensors

NRL Filter Breakthrough Tests*



Date: 01/31/2000
Length of Trial: 9.00 hr
Sample Rate: 10/min
DMMP: 1500 mg/m^3 (300 ppm)
Flow rate = 10 Lpm. T = 30^{0}C
%RH = House Air
Sensor position:
middle of 2.5 cm bed
Breakthrough time @ 4000 sec.

Data from NRL
R. Andrew McGill

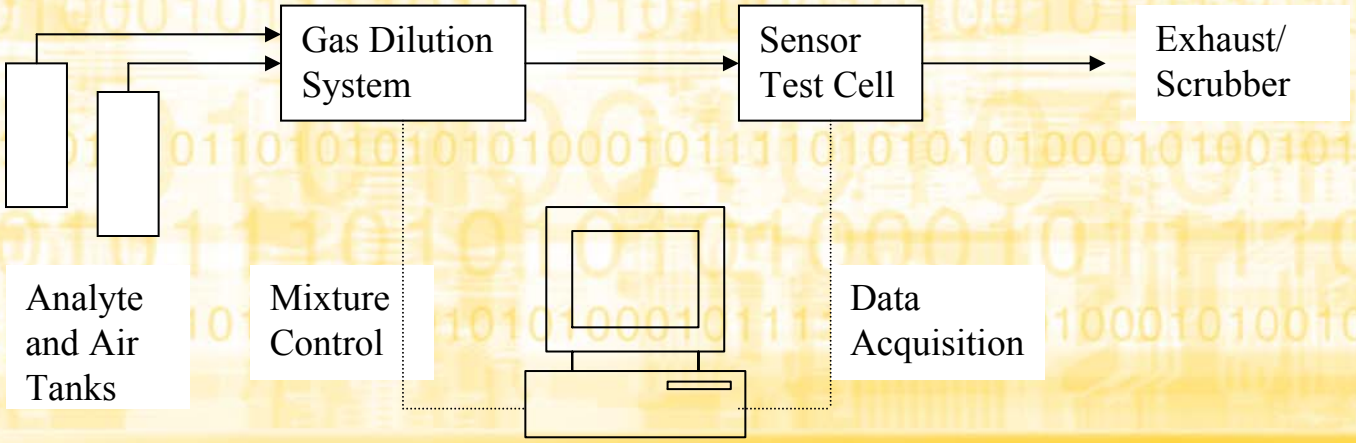
Cyrano chemiresistor technology successfully used as Filter Breakthrough/Residual Life Indicator

NIOSH
RLI for Air Purifying Respirators

- Contract awarded for further development of Residual Life Indicator (RLI) technology.
- 3 part program includes:
  - Determination of detection limits and sensor selection
  - Filter breakthrough detection
  - Development of prototype mask/detector system
- One year program; prototype detector systems delivered June 2003

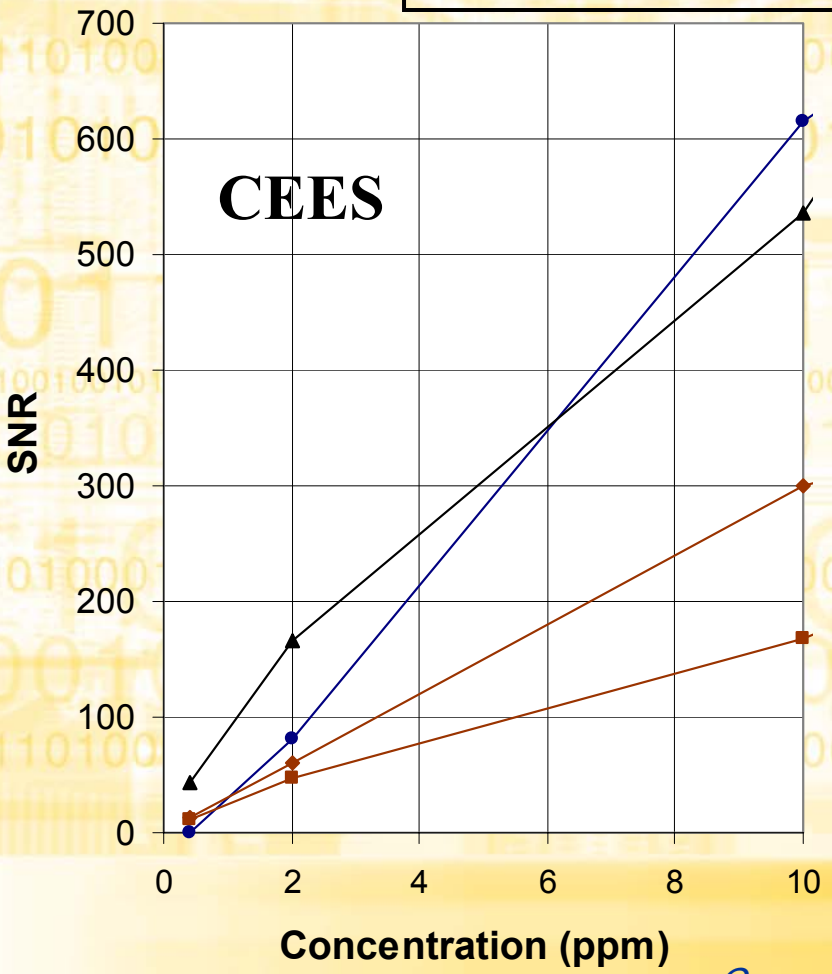
Determination of Detection Limits

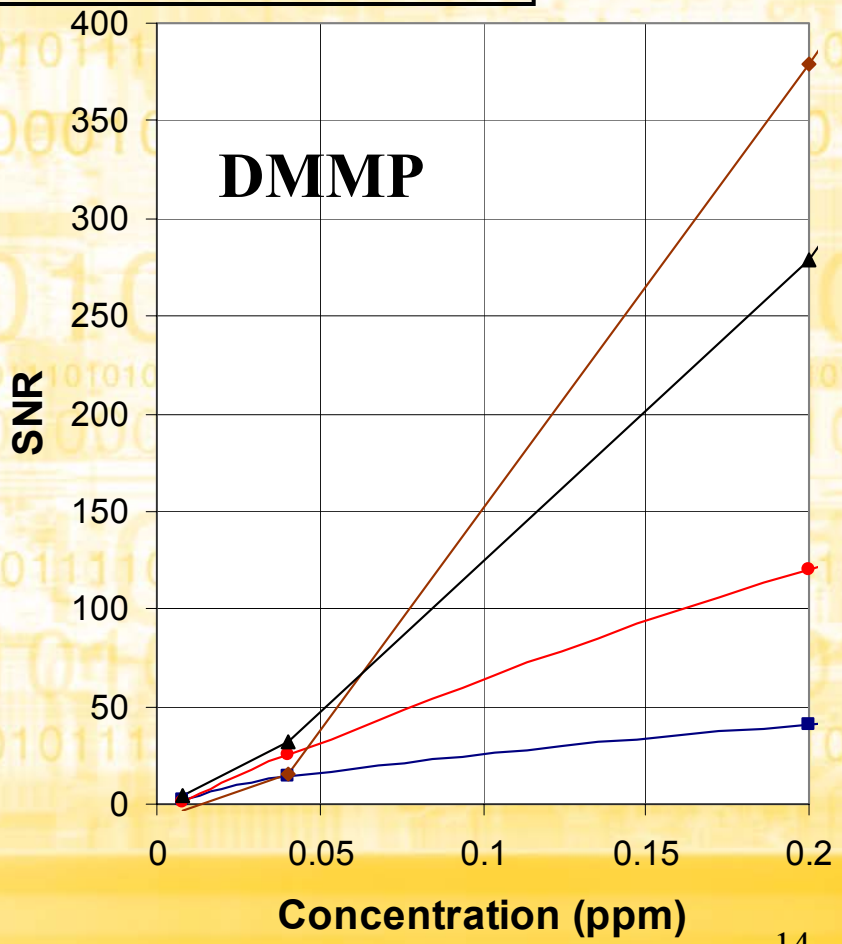
- Determine detection limit of 10 VOC's chosen by NIOSH using system illustrated below
- Select sensors for breakthrough testing by "ranking" them according to detection limit to different chemical families



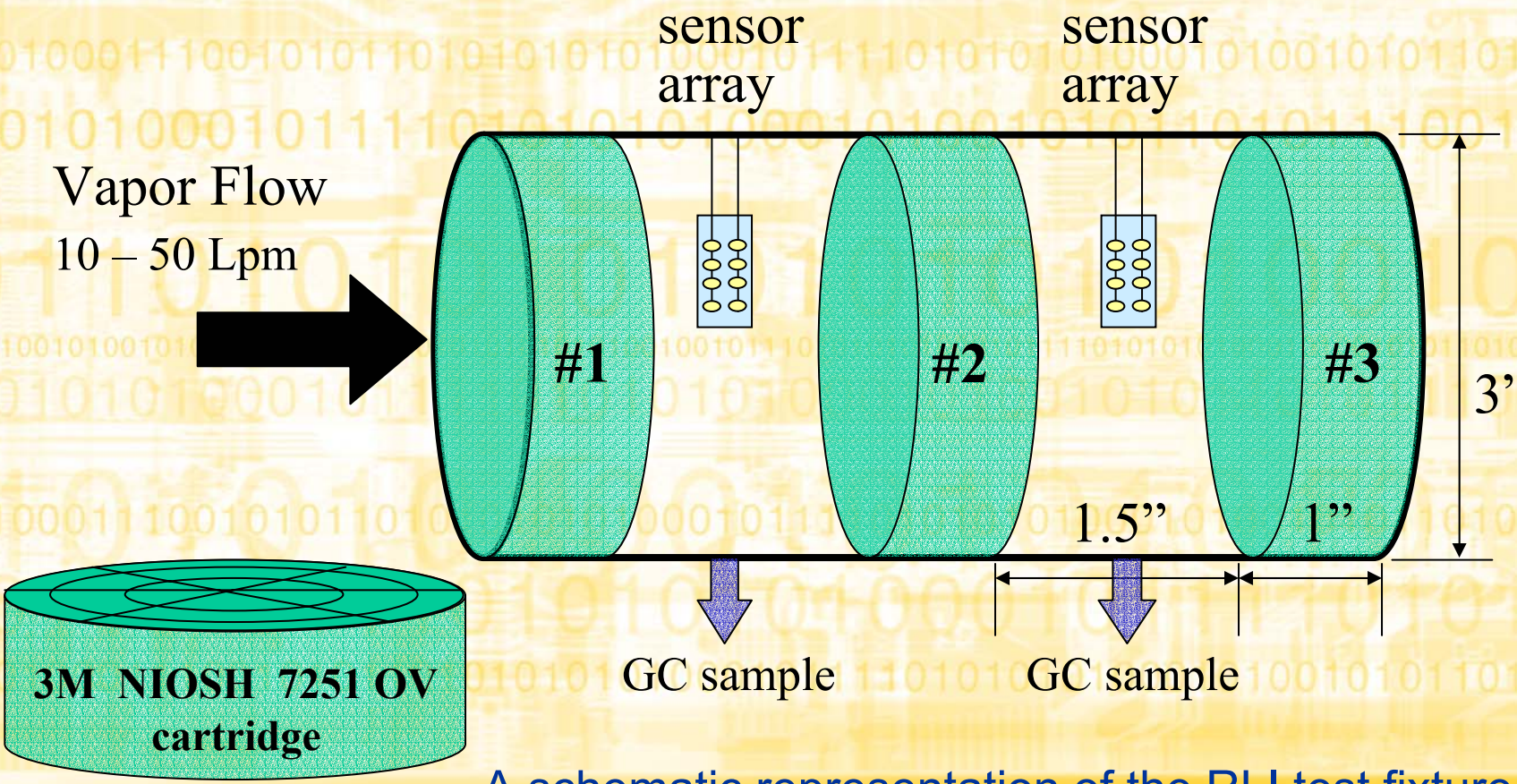
MDL Studies for TICs, CWA

Ammonia	SNR > 100 at REL 25 ppm
Nitrogen Dioxide	SNR > 400 at REL 3 ppm
Phosgene	SNR > 10 at REL 2 ppm



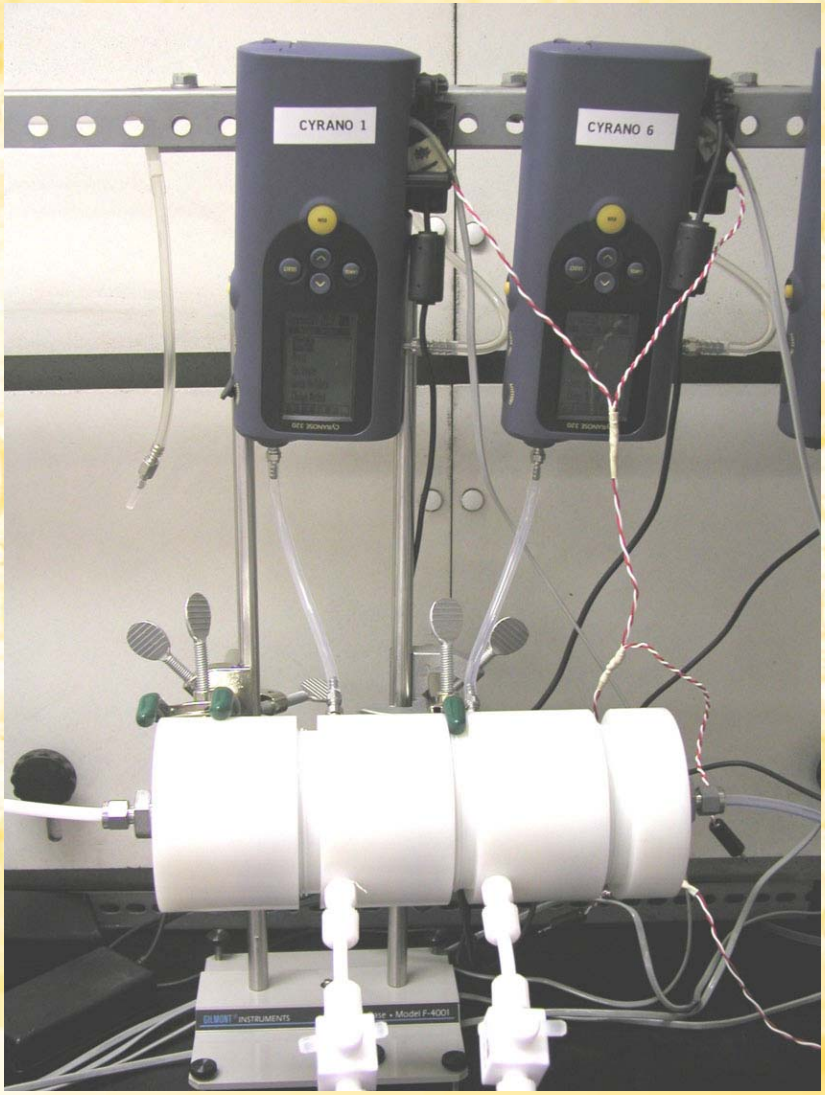


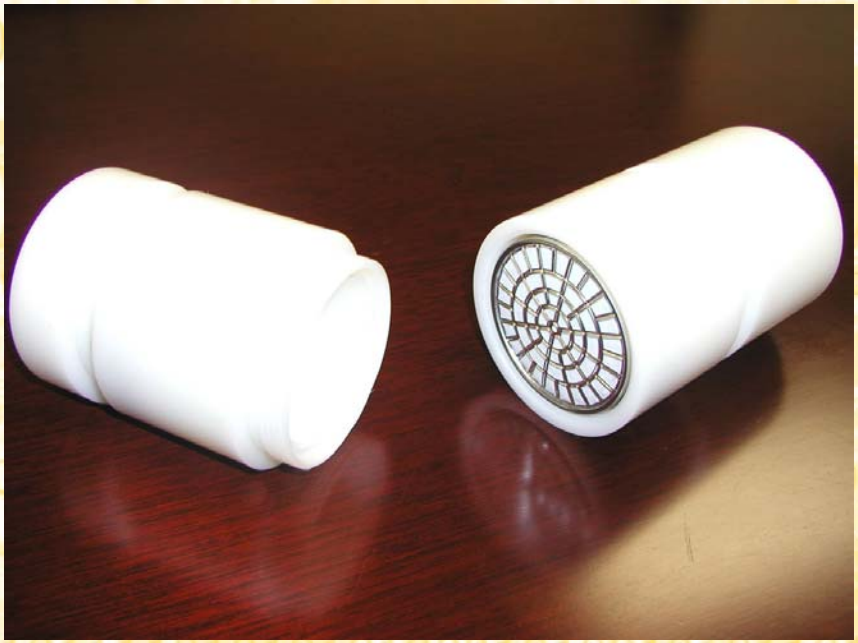
NIOSH Filter Breakthrough Test Bed



A schematic representation of the RLI test fixture

NIOSH Filter Breakthrough Test Bed



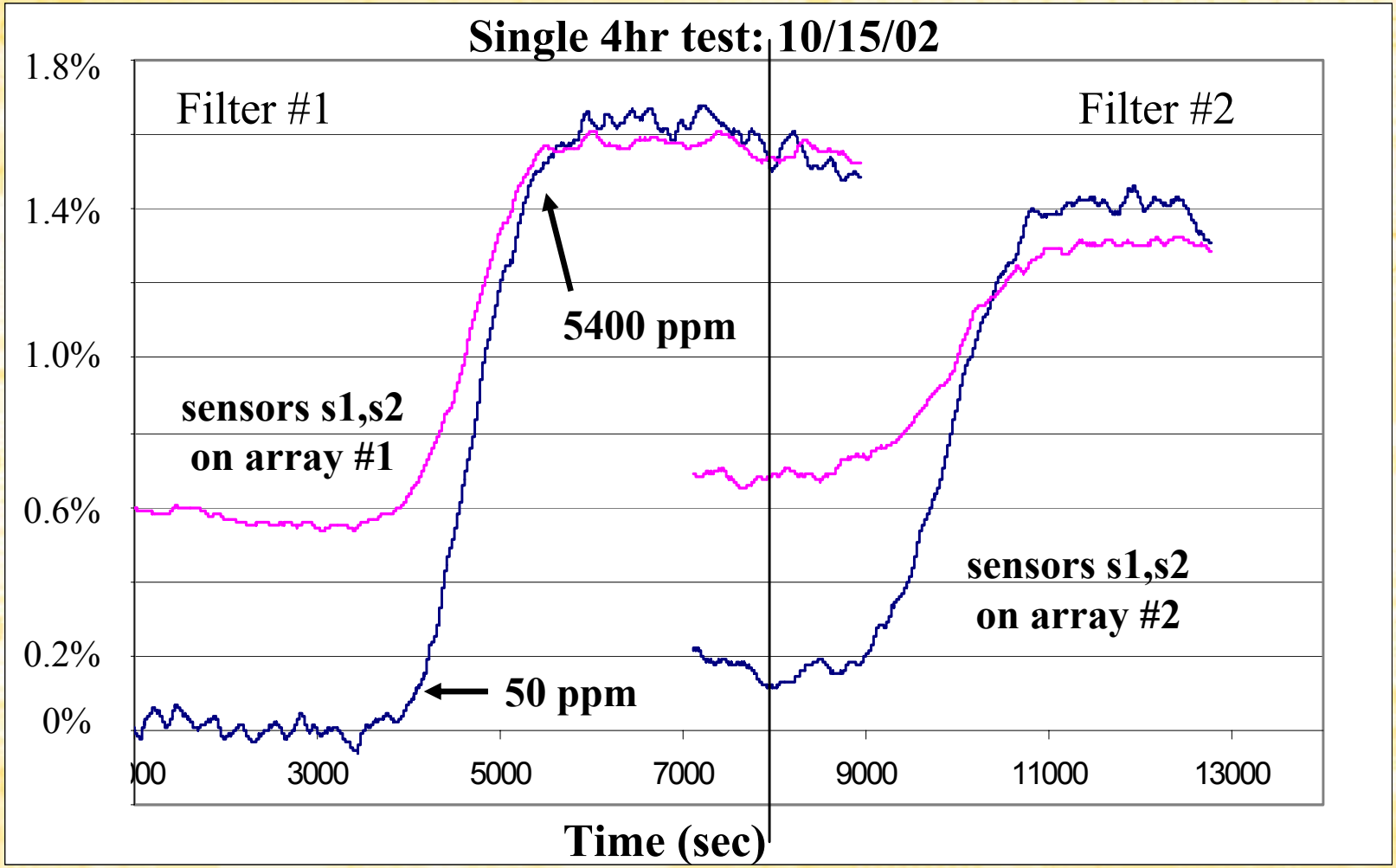


NIOSH
Vapor Generation System

Capabilities

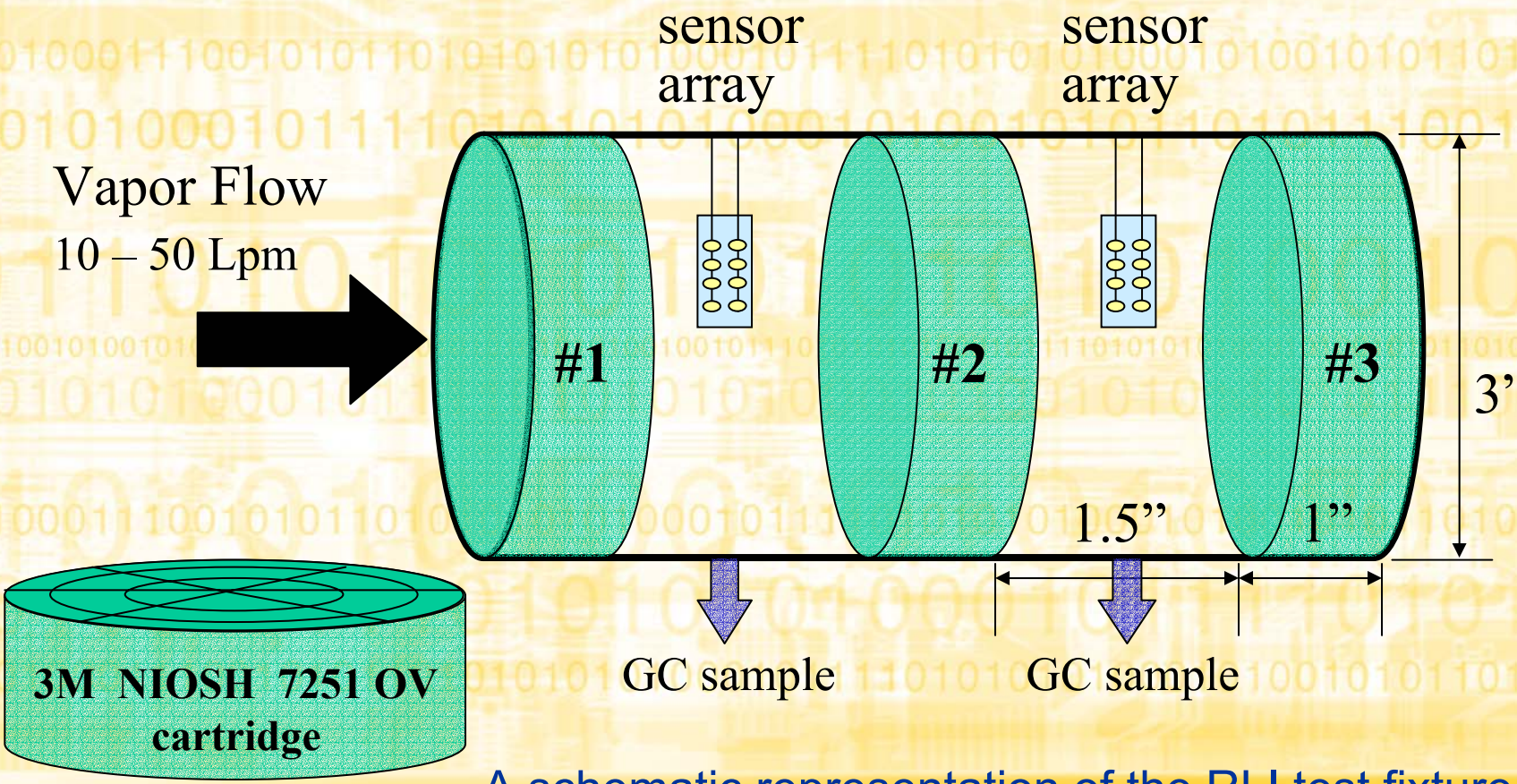
- Concentration:
  <1 ppm to Saturation
- Flow Rate:
  0.1 to 100 Lpm
- Solvents, TICs,
  CWA simulants
- Mixtures

Multi-Filter Breakthrough ("RLI")



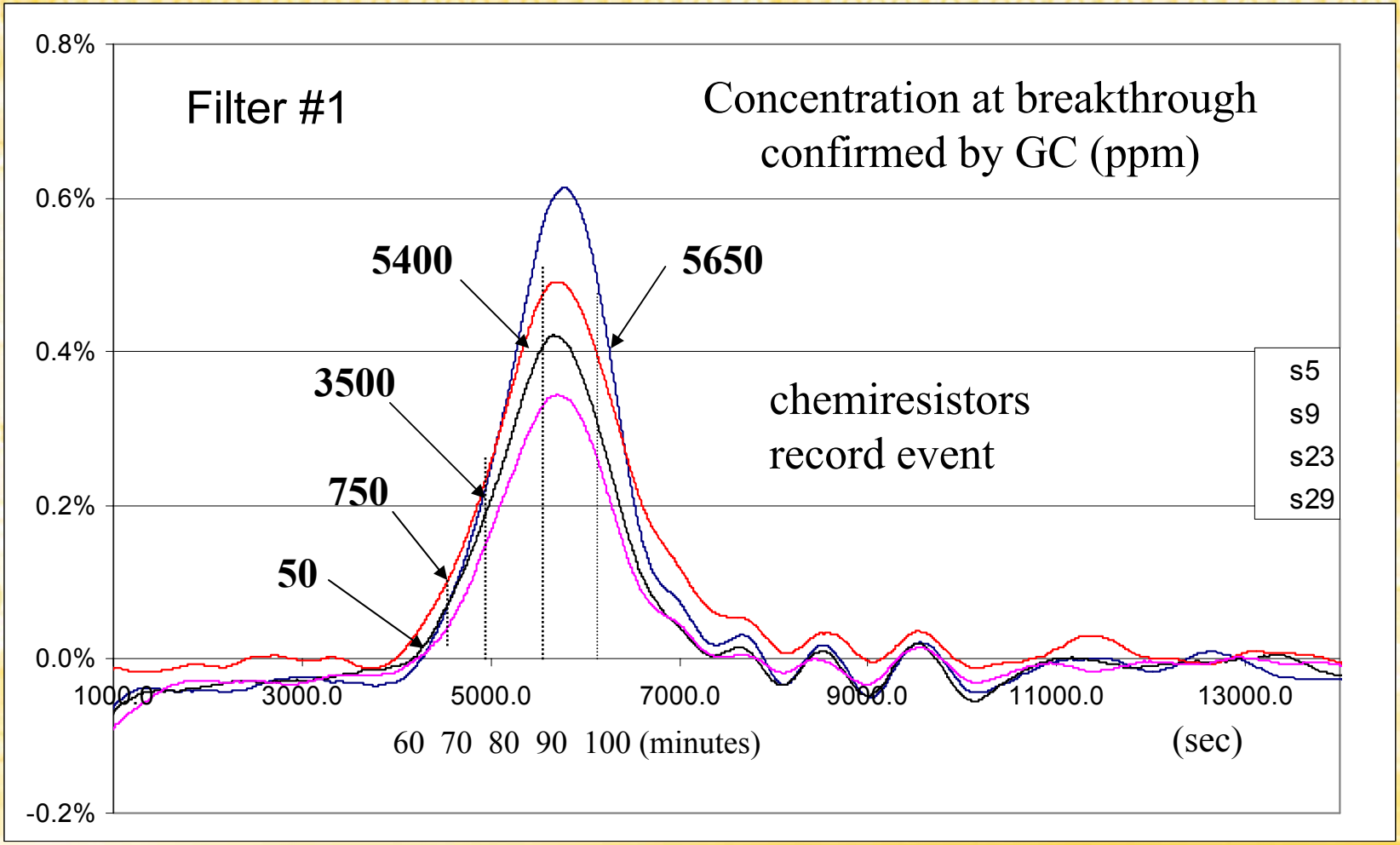
Challenge concentration 6000ppm

NIOSH Filter Breakthrough Test Bed

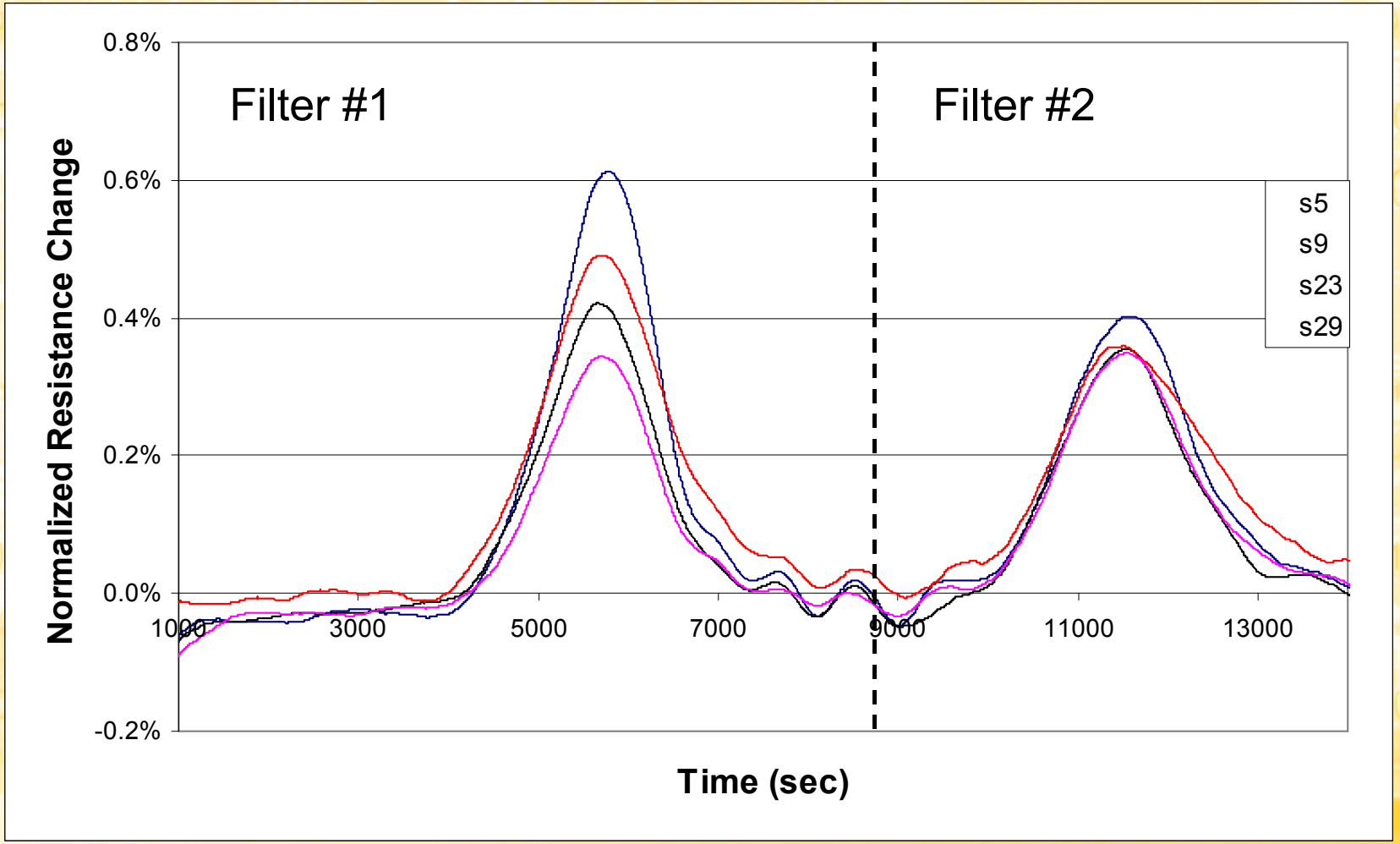


A schematic representation of the RLI test fixture

Breakthrough Event Detection



Breakthrough Event Detection



NIOSH Recommended Filter Challenge Vapors

Challenge Chemical	Test Conc. (ppm)	Breakthrough Conc. (ppm)	IDLH (ppm)	REL / TLV 8-hr TWA (ppm)	RLI Detector Reqt.
	draft	*draft*			
Cyclohexane	3900	10	1300	300	?
Ammonia	2500	12.5	300	25	?
Formaldehyde	500	1	20	< 1	?
Phosgene	250	1.25	2	0.1	?
Phosphine	300	0.3	50	0.3	?
Cyanogen Chloride	300	2	n.a.	0.3	?
Hydrogen Cyanide	1000	4.7	50	4.7	?
Hydrogen Sulfide	940	5	100	10	?
Sulfur Dioxide	1500	5	100	2	?
Nitrogen Dioxide	200	1	20	3	?